SECTION C Descriptions and Specifications

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**ADVANCED LIQUID WASTE THERMAL DESTRUCTION SYSTEM FOR SHIPBOARD LIQUID WASTE**

## 1. SCOPE

This contract is for the purchase of an advanced liquid waste thermal destruction system for installation aboard a small United States Navy Combatant for the 21st century. The thermal destruction system shall be based on commercial off-the-shelf (COTS) equipment that either meets the applicable requirements described herein or has been modified to meet these requirements. The system may be Navy fuel oil fired and/or powered by electricity. This thermal destruction system shall include all equipment, controls, structure, special tools and equipage associated with processing the target liquid waste streams (as described in section 3.6). This processing shall include the feeding, combustion, ash removal, and exhaust gas treatment that is essential to meet the requirements described herein. Shipboard integration components of incineration, including in feeding of waste, ash handling, service connections and exhaust ducting are not directly the responsibility of the thermal destruction system supplier. The U.S. Navy will process shipboard solid waste using recently designed solid waste management equipment.

The following work statement contains a performance specification along with specific data descriptions to ensure that the system meets U.S. Navy requirements.

## 2. APPLICABLE DOCUMENTS

### 2.1 General

The documents listed below are cited in this specification. In each case, the latest version or revision shall apply. They do not constitute a comprehensive list of thermal destruction system design specifications, but are used herein to define Navy requirements that may be above and beyond existing incinerator manufacturing practice. They shall be followed as described within this statement of work and to the extent that they define best commercial practice.

### 2.2 Government Specifications, Standards, and Handbooks.

The following specifications, standards, and handbooks shall be used by the offeror as background and guidance, either mandatory or as goals, to achieve the military requirements described in this statement of work.

2.2.1 Department of Defense

MIL-STD-461E - Control of Electromagnetic Interference and Emissions and Susceptibility, Requirements (Guidance)

MIL-S-901C - Grade B Shock Requirements for Shock Tests, Shipboard Machinery, Equipment, and Systems (Guidance)

MIL-STD-740B Airborne and Structureborne Noise Measurements and Acceptance Criteria of Shipboard Equipment (Mandatory)

MIL-STD-882 – System Safety Program Requirements (Mandatory)

MIL-STD-1399 – Interface Standard for Shipboard Systems (Guidance)

MIL-DTL-5624T - Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-5/JP-8 ST (Guidance)

MIL-F-16884J Fuel, Naval Distillate (Guidance)

MIL-HDBK-781 Reliability Test Methods, Plans and Environments for Engineering Development, Qualifications, and Production (Guidance)

NAVSEA publication “Metric Guide for Naval Ship Systems Design and Acquisition” dated June 1995 (Guidance)

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Standardization Documents Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government Documents, Drawings

OPNAVINST 5090.1B Change 2, Environmental and Natural Resources Program Manual Department of Navy, Office of the Chief of Naval Operations, Washington, DC 203050 (Guidance)

**2.3 Commercial Specifications.**

2.3.1 American Society For Testing And Materials (ASTM)

ASTM F1166-95a, Standard Practice for Human Engineering Design for Marine Systems, Equipment and Facilities (Guidance)

ASTM F1323-98, Standard Specification for Shipboard Incinerators Mandatory)

ASTM F1155-98, Standard Practice for Selection and Application of Piping System Materials (Mandatory)

ASTM D-4541 - 85(89), Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers(Guidance)

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.)

2.3.2 Institute Of Electrical And Electronics Engineers (IEEE)

IEEE 45-1998 Recommended Practice for Electric Installations on Shipboard (Mandatory)

Application for copies should be addressed to the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331.)

2.3.3 INTERNATIONAL MARITIME ORGANIZATION (IMO)

MARPOL Annex VI, International Convention for the Prevention of Pollution (1997)from Ships, Annex VI, Emission Standards for Shipboard Incinerators with Capacities of up to 1,160kw (Mandatory Requirement for CO and Soot number only).

(Application for copies should be addressed to the Publication Section IMO, 4 Albert Embankment, London SE1 7SR, UK.)

2.3.4 INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 6954 (15 December 1984), Mechanical Vibration and Shock Guidelines for the Overall Evaluation of Vibration in Merchant Ships. First Edition (Guidance)

(Application for copies should be addressed to the International Organization for Standardization, Case Postale 56, Geneva, Switzerland CH-1211.)

2.3.5 AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME Y14.100M-1998: Engineering Drawing Practices (Guidance)

ASME Y14.5M-1994: Dimensioning and Tolerancing (Guidance)

(Application for copies should be addressed to ASME International, Three Park Avenue, New York, NY 10016-5990)

2.3.6 STEEL STRUCTURES PAINTING

SSPC-SP10 (or NACE No. 3): Joint Surface Preparation Standard, Near-White Blast Cleaning (Guidance)

(Application for copies should be addressed to the Steel Structures Painting Council, 40 24th Street, Suite 600, Pittsburgh, PA 15213 USA Phone: 412-281-2331 Fax: 412-281-2331 Email: research@sspc.org)

2.3.7 SOCIETY OF NAVAL AND MARINE ENGINEERS

SNAME T&R Bulletin No. 3-37: Design Guide for Shipboard Airborne Noise Control (Jan 1983)(Mandatory)

(Application for copies should be addressed to SNAME, 601 Pavonia Ave., Jersey City, NJ 07306)

**2.4 Order of Precedence.**

In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless the contractor has obtained a specific exemption from the Government by way of the Contracting Officer.

**3. DESIGN REQUIREMENTS**

The requirements described below define the advanced liquid waste thermal destruction system design specifications. The manufacturer shall consider total ownership costs when conducting trade-off studies to determine best value. The costs for manning, maintenance, and follow-up logistics shall be included in all analyses. A separate report and certification letter as detailed in Section 4 of this specification shall be provided to verify compliance with each requirement as described below.

**3.1 ASTM Incinerator Standard**

3.1.1 The system shall comply with ASTM F1323-98, Standard Specification for Shipboard Incinerators except where a waiver for a specific exception to this standard is applied for and granted, or where this specification overrides a specific requirement.

3.1.2 Section 5.1 in ASTM Specification F1323-98 does not apply to the primary combustion chamber.

3.1.3 Section 5.6 in ASTM Specification F1323-98 does not apply to the shock cooling system.

**3.2 Compatibility with Ship's Services**

The advanced thermal destruction system as defined in this specification shall be defined according to the following subdivisions:

Main thermal destruction system assembly – This shall consist of the combustion chamber(s), pretreatment and feed systems along with associated refractory, burner(s) and other directly attached components. Conduit, ducting and piping attached to this assembly, to the extent that it within the habitable compartment volume (from the deck to 6.5-ft above the deck) also is considered part of the main thermal destruction system assembly.

Auxiliary equipment – This shall consist of equipment and components that support the main thermal destruction system assembly, but which can be mounted in a remote location. This may include oil holding tanks, fans, blowers and pumps.

Thermal destruction system exhaust treatment and handling equipment – This shall consist of thermal destruction system exhaust treatment and handling equipment including ducting, water injection and removal equipment, and exhaust blower.

3.2.1 The shipboard services that are available for the thermal destruction system are:

- 440V, 60-Hz, 3-phase electrical power
- Seawater at 100 – 175 PSIG (690 – 1.206 kPa) (Actual value will vary over time and depending on shipboard location)
- Fresh Water (for System Cleaning)– 60 PSIG (414 kPa) up to 10 GPM; 70°F (21°C), total usage shall be minimized under normal operating conditions.
- Ship service compressed air at 125 PSIG (862 kPa) (Air supply to the space at a maximum temperature of 90°F (32.2 °C) with a wet bulb temperature of 81°F (27.2 °C))
- Aviation Turbine Fuel Oil – JP-5 or NATO designation F-44
- Naval Distillate, DFM or NATO F-76
- Compartment Ventilation - As Required

3.2.2 Considerations for Ducting and Piping

Consideration must be given to allow for conduit, ducting and piping installations that are feasible, serviceable, simple to install, and will provide good performance. The design requirements for connecting the main thermal destruction system assembly with utilities (e.g. water, electric) and remotely located components, such as blowers and fuel oil day tanks shall comply with the following guidelines:

- The conduit, ducting and piping and associated components that would exist within the operational envelope cannot impede the ability for the operator or maintainer to perform operation and maintenance from within that envelope. Also, it shall not create any personnel hazards.

- Removal of conduit, ducting or piping shall not be required to perform any normal maintenance or repair.

- Removal of conduit, ducting or piping should only be required for thermal destruction system installation or removal or for ducting/piping clean out.

- The design of conduit, ducting and piping should assume that they can be routed either through an overhead space that is up to 6-inches in vertical height or beneath the deck in a space that exists between deck support beams and is up to 6-inches in vertical height.

**3.3 Weight**

The goal for the main thermal destruction system assembly equipment weight is less than 10,000-lb (4,536-kg), however, the total weight of the entire installed system shall not weigh more than 14,000-lb (6,350-kg).

- The weight of the entire thermal destruction system unit less exhaust gas treatment and exhaust stack shall be less than 10,000 lb. (4,536 kg).
- The weight of exhaust gas treatment system less exhaust stack and flue gas fan if required shall be less than 2,000 lb. (907 kg).
- The weight of exhaust stack and flue gas fan required shall not be more than 2,000 lb (907 kg).
- The total weight of the entire installed system shall not weigh more than 14,000 lb (6,350 kg).

**3.4 Thermal Destruction System Size**

The advanced liquid waste thermal destruction system, including the combustion chamber, structure, and any pretreatment equipment, shall have an installation/operating/maintenance envelope that would be compatible with a small combatant, with a goal of 10-ft x 12-ft (3.0-m x 3.7-m) or smaller. All operation/maintenance shall be performed without requiring any part of the operator/maintainer’s body to extend out past this envelope. No component or assembly will be taller than 6.5-ft (2-m).

**3.5 Modularity**

On U.S. Navy ships the thermal destruction system compartment location may require the thermal destruction system to be transported through other ship compartments prior to assembly and installation. In order to achieve this, a goal of this effort is to perform installation by assembling the thermal destruction system using modular components rigged through standard ship watertight doors and passageways. Standard ship watertight hatches measure 26-in. x 66-in. (0.66-m x 1.68-m). The main thermal destruction system assembly shall be constructed so that it can be assembled in place in a compartment that is one deck high; equipment height is limited to 6.5-ft (1.98-m). The thermal destruction system assembly installation is to be accomplished to the greatest extent possible by assembling modular components so that the equipment does not have to be rigged into the installation space as a complete assembly. Note: All maintenance and replacement parts shall be capable of passing through standard ship watertight hatches and passageways.

**3.6 Waste Stream Processing Capability**

The advanced liquid waste thermal destruction system shall be capable of safely and completely processing the entire targeted concentrated liquid waste stream of 471-gal/day of shipboard non-oily and oily wastes within any 24-hour period. It shall be capable of being operated under normal shipboard conditions and motions, including a roll of up to 30-degrees to either side of the vertical, and a pitch of up to 10 degrees up or down from its normal horizontal plane, with an event duration period of 10-20 seconds. Navy shipboard liquid wastewater is generally classified as either non-oily or oily waste. The non-oily wastes include blackwater and graywater. Non-oily wastewater generation is dependent on crew size. Blackwater or sewage is the wastewater generated by water closets and urinals. Graywater is non-oily wastewater generated by showers and washbasins; galley, sinks, scullery equipment, and laundry equipment. Oily wastes are bilge water and waste oil. Bilge water originates as seal and equipment leaks, condensation, evaporator dumps, and fuel strippings. It consists primarily of water (approximately 99 percent) with small amounts of marine diesel fuel, lubricating oil, and a mixture of general purpose detergent and cleaning solvent. Waste oil may contain up to 20 percent emulsified water, equal amounts of lubricating oil and marine diesel fuel or JP5. Waste oil contains approximately 80 percent oil with the balance being water. Oily wastewater generation is dependent on the type of shipboard equipment installed. The anticipated daily liquid waste stream is described later in this specification. For the purpose of estimating a minimum acceptable processing rate, each 24-hour period is to include estimated times for startup, shutdown, ash removal, cool down and the maximum anticipated preventative and corrective maintenance times that would be expected. An average processing rate of 39 gal./hr or greater of the target waste streams is required. A thermal energy balance must be shown, using the target waste stream described in section 3.6.1.

3.6.1 Waste Stream Definition

The target concentrated liquid waste stream is described in Table 1; categories of waste are given along with their anticipated daily generation rates and approximate heat of combustion values. The Navy is currently developing technologies to treat or reduce the generation of blackwater, graywater, bilgewater, and waste oil aboard surface ships. The equipment and treatment of liquid waste streams is outside the scope of this announcement. Shipboard waste streams are not homogenous and significant variations both in composition and quantity should be anticipated throughout the day. Peak loading of graywater and sewage will occur around meal times. The concentrated oily wastewater is expected to be generated at a low flow rate over a duration of a day. Waste oil will be generated intermittently. The thermal destruction system must be capable of processing the waste automatically.  The waste may consist of either a single target waste category or any mixture of waste categories. Subsequent waste mixtures may vary randomly. The waste streams will be pumped to the thermal destruction system. An analysis of typical vacuum collected sewage is given in table 2. An analysis of graywater concentrate is given in table 3. An analysis of typical shipboard oily wastewater concentrate is given in table 4 and an analysis for waste oil is given in table 5, note that a significant amount of water can be found in shipboard waste oil tanks. Oil and water layers exit. The disposal of used oil filters is outside the scope of this announcement.

### 3.6.2 Waste Stream Incidental Items

Incidental items, including paint thinner and cleaning solvent, may be feed into the thermal destruction system. These wastes are found in oily wastewater (bilge water) and expected to have relatively low concentration levels, approximately 100 ppm but may be potentially disruptive to thermal destruction system performance. Other incidental items that may be found in sewage include cigarette butts, personal hygiene products, and batteries. The thermal destruction system shall be designed to safely tolerate these wastes, if they are accidentally introduced, without endangering the operators or equipment. No damage shall be caused by these items, nor will, any thermal destruction system downtime result.

Table 1. Target Concentrated Waste Streams

| **Category (Source)** | **Approx. Amount l/day (gal/day)** | **Heat of Combustion dry Value* J/kg (BTU/lb)** |
|---|---|---|
| Sewage (VCHT Water closets and urinals) | 1136 (300) | $12.5x10^6$ (5360) |
| Graywater Concentrate, (Food service (33%); Lavatories (45%), laundry(22%)) | 568(150) | $21.2x10^6$ (9100) |
| Oily wastewater concentrate | 11-23 (3-6) | Not detected |
| Waste oil | 38-57 (10-15) | $44.4x10^6$(18600-19600) |
| **Total** | 1753-1784 (463-471) | Not Applicable |

*This represents a typical value; however some waste streams may have a heat value that is 20% above this.

Table 2. Vacuum Collected Sewage (Blackwater) Analysis

| Analytical Parameter | Method | Test Value |
|---|---|---|
| Ultimate Analysis | ASTMD3176m | Results |
| Total Moisture | ASTMD1744 | 98.03% |
| Ash | ASTMD3176 | 0.25% |
| Carbon | ASTMD3176 | <.05-.5% |
| Hydrogen | ASTMD3176 | 11.44% |
| Sulfur | ASTMD3176 | <0.5% |
| Oxygen, by difference | ASTMD3176 | 88.25% |
| Nitrogen | ASTMD3176 | <0.5% |
| Chlorine | ASTMD3176 | 0.03% |
| Percent Total | ASTMD3176 | 100.00% |
| | | |
| Proximate Analysis | ASTMD3172 | Results |
| Total Moisture | ASTMD31744 | 98.03% |
| Ash | ASTMD3172 | 0.25% |
| Volatile Matter | ASTMD3172 | 1.61% |
| Fixed Carbon | ASTMD3172 | 0.11% |
| Percent Total | ASTMD3172 | 100.00% |
| Heat of Combustion-dry | ASTMD240m | 5360 BTU/lb |
| Sulfur | EPA 375.3 | 0.01% |
| | | |
| Viscosity @20 deg C (Brookfield) | ASTMD2669m | 2.2 cP |
| Viscosity @40 deg C (Brookfield) | ASTMD2669m | 1.6 cP |
| Gravity, API(Hydrometer) | ASTM287 | 9.4 @60 deg API |
| Specific Gravity | ASTM 1298 | 1.004 |
| | | |
| Chloride | EPA 325.2 | 1300 mg/L |
| Calcium | EPA 200.7 | 110-380 mg/L |
| Lead | EPA 200.7 | <.20 mg/L |
| Magnesium | EPA 200.7 | 64 mg/l |
| Phosphorus (Total) | EPA 200.7 | 130-460 mg/l |
| Potassium | EPA 200.7 | 320-410 mg/l |
| Sodium | EPA 200.7 | 830-1100 mg/l |
| Solids (suspended) | EPA 160.2 | 3300-18,000 mg/l |
| Solids (Volatile) | EPA 160.4 | 4500-17,000 mg/l |
| Solids (Total) | EPA 160.3 | 8400-23,000 mg/l |
| Total Nitrogen | EPA 351.2 | 1300 mg/l |
| Oil & Grease | EPA 413.1 | 59-280 mg/l |
| | | |

Table 3. Graywater Concentrate Analysis

| Analytical Parameter | Method | Test Value |
|---|---|---|
| Ultimate Analysis | ASTMD3176m | Results |
| Total Moisture | ASTMD1744 | 96.92% |
| Ash | ASTMD3176 | 0.14% |
| Carbon | ASTMD3176 | <.56% |
| Hydrogen | ASTMD3176 | 11.38% |
| Sulfur | ASTMD3176 | <0.05% |
| Oxygen, by difference | ASTMD3176 | 87.92% |
| Nitrogen | ASTMD3176 | <0.05% |
| Chlorine | ASTMD3176 | 0.01% |
| Percent Total | ASTMD3176 | 100.00% |
| | | |
| Proximate Analysis | ASTMD3172 | Results |
| Total Moisture | ASTMD31744 | 96.92% |
| Ash | ASTMD3172 | 0.14% |
| Volatile Matter | ASTMD3172 | 2.85% |
| Fixed Carbon | ASTMD3172 | 0.09% |
| Percent Total | ASTMD3172 | 100.00% |
| Heat of Combustion-dry | ASTMD240m | 9100 BTU/lb |
| Sulfur | EPA 375.3 | 0.007% |
| | | |
| Chloride | EPA 325.2 | 1300 mg/l |
| Solids (suspended) | EPA 160.2 | 3234-18000 mg/l |
| Solids (Volatile) | EPA 160.4 | 11000 mg/l |
| Solids Total | EPA 160.3 | 18000 mg/l |
| Salinity | | 2.1 to 18.7 % |

Table 4. Oily Wastewater Concentrate Analysis

| Analytical Parameter | Method | Test Value |
|---|---|---|
| Ultimate Analysis | ASTMD3176m | Results |
| Total Moisture | ASTMD1744 | 99.80% |
| Ash Dry Basis | ASTMD3176 | <0.01% |
| Carbon Dry Basis | ASTMD3176 | <0.5% |
| Hydrogen Dry Basis | ASTMD3176 | 11.04% |
| Sulfur Dry Basis | ASTMD3176 | <0.05% |
| Oxygen, by difference Dry Basis | ASTMD3176 | 88.96% |
| Nitrogen Dry Basis | ASTMD3176 | <0.05% |
| Chlorine Dry Basis | ASTMD3176 | 0.05% |
| Percent Total | ASTMD3176 | 100.00% |
| | | |
| Proximate Analysis | ASTMD3172 | Results |
| Total Moisture | ASTMD31744 | 99.80% |
| Ash Dry Basis | ASTMD3172 | <0.01% |
| Volatile Matter Dry Basis | ASTMD3172 | NA |
| Fixed Carbon Dry Basis | ASTMD3172 | NA |
| Percent Total | ASTMD3172 | 100.00% |
| Heat of Combustion-dry | ASTMD240m | Incombustible BTU/lb |
| Sulfur | EPA 375.3 | 0.025 % |
| Vapor Pressure (Min. Method) | ASTMD4953 | 1.2 psi |
| Actual Oil | 352 to 609 mg/l | 2.57 to 4,318 mg/l |

Table 5. Typical Analyses of Waste Oil

| Analytical Parameter | Concentration Mean | Concentration Range |
|---|---|---|
| Flash Point (oF) | 135.6 | 100 to >212 |
| Heating Value (Btu/lb) | 19,240 | 18,600 to 19,600 |
| Total Suspended Solids (TSS) | 477.6 | 5 to 668 |
| Total Sulfur (%) | 0.23 | 0.17 to 0.34 |
| Ash (%) | 0.45 | 0.10 to1.55 |
| Lead | NA | NA |
| Chromium | NA | NA |
| Cadmium | NA | NA |
| 1,1,1-Trichloroethane (ppm) | 340 | <100 to <500 |
| Trichloroethane (ppm) | 680 | <200 to <1,000 |
| Freon 113 (ppm) | NA | NA |

| | | |
|---|---|---|
| Tricresylphosphate (ppm) | 1,400 | <900 to 3,400 |
| Glycols (ppm) | <10 | -- |
| Total Halogens (ppm) | 428 | <10 to 2,100 |
| T-butyl triphenylphosphate (ppm) | <1,000 | -- |
| Density | | 0.85 to 0.87g/ml |
| Viscosity | | 6.1 to 44.6 cSt @ 100 deg. F |
| | | |

Note: Lead, chromium, cadmium, and freon-113 shall be prohibited from future ships.

**3.7 Waste Handling Feed System.**

The feed system needs to be designed to be automatically controlled. The feed system shall be designed to be operator friendly and safe. This system shall have features that prevent the propagation of combustion and smoke into the feed system and the ship's compartment. This equipment must fit and be maintainable within the constraints described in section 3.4. In addition, its design shall permit sufficient cleaning to guarantee that waste residues will not cause odor, health or habitability problems. Feed equipment shall be designed to allow continuous feeding of wastes. System piping shall be capable of wash down with a freshwater garden hose and shall be resistant to damage or maintenance impacts (e.g. clog, bridging or jamming with waste) that may occur from handling target wastes. The physical work that the thermal destruction system design requires, of the operator, for preparing and feeding of the waste shall be minimized and not require more than one operator. The feed system shall prevent the thermal destruction system from being overloaded with waste to a magnitude such that the control system cannot maintain the combustion process within allowable limits as defined in section 3.10. Interlocks shall prevent feeding before the combustion chamber has reached operating temperature and when the thermal destruction system is in a shutdown mode of operation. Also, the feed system shall not be the cause of any shut down of the incineration process unless it is for safety reasons arising from the introduction of waste whose characteristics fall outside the bounds of the targeted waste streams defined in paragraph 3.6.1.

**3.8 Combustion Chamber(s)**

3.8.1 Process/Temperature Control.

The thermal destruction system shall automatically control the combustion process to maintain efficient operation and protect internal components from damage. The exhaust stack exit temperature shall be as low as possible. The automatic control shall not require any operator feedback other than commands for process startup, emergency or normal shutdown and maintenance/ troubleshooting. The combustion technology must allow processing of all target waste as described in section 3.6.1 while maintaining emissions goals as described in section 3.10. In addition, calibration of sensors or gauges shall not be required more often than every 2400 hours of operation or once per year.

3.8.2 Operator Interface.

Operation of the thermal destruction system shall not allow operators to be directly exposed to the combustion chamber(s) or to radiant, convected or conducted heat from the combustion chamber(s).

3.8.3 Combustion Chamber Pressure.

The thermal destruction system shall maintain a negative internal pressure under all operating conditions sufficient to prevent smoke or combustion gases from entering the ship’s compartment.

### 3.9 Ash Collection and Handling

3.9.1 Ash/Slag Collection.

The thermal destruction system shall provide for the safe collection and removal of both bottom ash and slag with minimal interference to the combustion process. The process for the collection and removal of bottom ash and slag can be either of the following: (1) automatic and continuous without requiring shutdown (preferred) or (2) manual, requiring system shutdown. Ash removal must occur in the operational/maintenance envelope described in section 3.4. Manual collection of ash shall occur no more than once per seven-day operating period.

3.9.2 Ash/Slag Handling.

The thermal destruction system architecture shall not require undue exposure of the operator to temperatures above 140 °F (60 °C), ash, hazardous gases, or other thermal destruction system by-products during the process of handling ash or slag. The temperature of the ash being transferred shall be less than 428 °F (220 °C). There shall be no obstructions around the ash removal door that can cause accidental exposure of maintenance personnel to ash either directly or through the air. The flue gas fan should be kept on to ensure that all bottom ash that becomes airborne does not enter the compartment.

3.9.3 Ash Total Ownership Costs

The thermal destruction system manufacturer shall consider total ownership costs when conducting trade-off studies to determine the best value for removal and collection of ash. The costs of ash removal and collection (manning), maintenance of equipment, and follow-on logistics support of the ash collection system, and its associated support systems shall be analyzed. Also, the costs connected with environmental considerations and ash disposal shall be analyzed.

### 3.10 Exhaust Gas Treatment and Emission Requirements

3.10.1 Emission Requirements.

The emission requirements listed in Table 6 shall be met when processing all combinations of target waste, as listed in Table 1, and for all potential operating scenarios. Possible operating scenarios include the feeding of subsequent batches of the highest and lowest possible heat value wastes, and feeding at any rate up to the maximum that the thermal destruction system controls allow.

Table 6. Advanced Liquid Waste Thermal Destruction System Emission Requirements

| Type of Emission | Limit |
|---|---|
| **CO in flue gas max avg.** | 200 mg/MJ corrected to 7%Oxygen |
| **Soot number (A higher soot number is acceptable only during very short periods such as start up)** | Bacharach 3 or Ringelman 1 (<20% Opacity) |

3.10.2 Shock Cooling Sub-System

The system shall provide for a rapid quench of the exhaust gas (with salt water or air) exiting the combustion chamber to minimize the formation of dioxins and furans. In all cases the minimum temperature of the flue gas entering the water quench sub-system shall be greater than 1110°F (600 °C) and shall be shock cooled below 390 °F (200 °C) in less than 1 second of residence time. This subsystem shall also neutralize acidic gases to a pH of not less than 5.0 and sufficiently reduce the relative humidity to ensure that condensation will not occur in the exhaust stack or at the stack exhaust point. This subsystem installation envelope may extend outside of the installation/operational/maintenance envelope limitations described in section 3.2, provided any maintenance and repair to it that may be required for anticipated shipboard maintenance and repair can be accomplished from within that envelope. Safety interlocks shall be provided to ensure that the thermal destruction system cannot be operated if the shock cooling sub-system is not functioning properly.

3.10.3 No Visible Plume.

The system shall not exhibit a visible steam plume from the output stack at 32 °F (0 °C) ambient. The exhaust stack exit temperature shall be as low as possible. The stack shall operate without the emission of visible sparks or fly ash particles from the exhaust gas outlet.

**3.11 Exhaust Stack Sizing.**

The exhaust stack size diameter shall be approximately 1-ft (.3 m). The government will provide exhaust stack insulation.

**3.12 Control and Alarm Requirements:**

3.12.1 Process Monitoring.

The system shall provide sufficient process monitoring and automated controls to maintain controllable, stable, safe and non-destructive operating conditions. It is required that thermal destruction system data be capable of being remotely accessed. This data is to be used to obtain system condition and monitor for degraded operating capacity or alarm conditions. Set Points for low/high combustion temperature, low/high flue gas temperature, $O_2$ level and any other parameter required by the manufacturer to control the incineration process are to be determined by the offeror. The set points shall represent the operating end points within which the thermal destruction system will meet the exhaust gas requirements described in section 3.10.

3.12.2 Alarms.

The system shall provide warning alarms for any operating condition that results in the thermal destruction system exceeding acceptable operating conditions, including those that require action by the operator. These include, but are not limited to, high combustion chamber temperatures, improper exhaust draft, or improper burner operation (e.g. low fuel oil pressure).

3.12.3 Failsafe Operation.

The system shall provide for an automatic fail-safe shut down capability for any operating condition that may result in damage to the system, or endanger the ship or personnel. The system shall prevent damage to the operator or equipment during the sudden and total loss of any one service. Safety interlocks shall be provided to ensure that while the thermal destruction system is in operation, ship personnel shall not be able to access any area of the thermal destruction system that can cause harm to either themselves or equipment. The interlock devices shall be resistant to damage from accidental impact from hand-carried objects, shock loading and compromise by ship personnel (i.e. they shall not be easily over-ridden by ship personnel wanting to compromise them). Interlock latches shall not require adjustment and shall be able to withstand shock loads.

3.12.4 Thermal Destruction System Control Panel.

The thermal destruction system control/operator interface shall clearly communicate all information to the operator that is required to ensure efficient and safe operation of the thermal destruction system process. It shall also provide sufficient information to allow shipboard repair personnel to facilitate troubleshooting and repair.

3.12.5 Emergency Shutdown.

Provision shall be made for a remote (outside of the thermal destruction system compartment) external Emergency Stop Control Switch to initiate a thermal destruction system shutdown.

**3.13 Electrical Systems**

The thermal destruction system electrical systems shall comply with IEEE 45-1998. The electrical systems shall be designed to minimize radiated and conducted electrical emissions and shall not be susceptible to electrical fields. For example, current shipboard waste equipment meet requirements that limit radiated emissions to less than 36 decibels above 1 micro-volt/meter at 100 MHz (measured at 1 meter from the equipment). Also shipboard waste equipment is not susceptible to electrical fields up to 10 Volts/meter. All electrical cables used shall be of the low smoke type. The ship’s power to be supplied to the system will be 440V - 60 Hz, 3-phase, 3-wire, ungrounded. Supplied power will be in accordance with IEEE 45-1998 and MIL-STD 1399.

**3.14 Piping Systems**

All piping in the system shall be designed and installed in accordance with the requirements of ASTM F1155-98, Standard Practice for Selection and Application of Piping System Materials. Any gages or meters that require calibration shall be connected to the piping by fractional English threads (e.g. ¼-in. NPT).

**3.15 Equipment Life, Reliability and Maintainability.**

The reliability and maintainability characteristics of the liquid waste thermal destruction system shall ensure that the crew of a small U.S. Navy combatant can, with a high degree of confidence, consistently dispose of the target waste stream, as defined in section 3.6, for a 6 month underway period.

3.15.1 Life Expectancy.

The liquid waste thermal destruction system shall be designed and constructed to provide a 25-year operational life with a minimum of maintenance and repair. The system shall be designed for a service life of at least ten years, at which point more extensive repair modifications, such as replacing refractory liner, can be performed.

3.15.2 Cleanliness.

The system shall be designed to facilitate the ease of cleaning and minimize manning requirements and life cycle costs while insuring the safety of the ship's personnel who are performing the cleaning procedures. The creation of inaccessible, hard to clean areas shall be avoided. Areas that collect debris or water shall be avoided in the design. Automated flushing/rinsing systems shall be provided as appropriate.

3.15.3 Reliability Requirements.

The design of all components shall be consistent with a marine environment. The liquid waste thermal destruction system shall have a Mean Time Between Critical Failures (MTBCF) of greater than 2,160 hours. A critical failure is defined as one that requires the thermal destruction system to be non-available for service for a time period that prevents processing of that day's waste.

3.15.4 Maintainability.

Routine cleaning and preventive maintenance shall not exceed one hour per week. For organizational level corrective maintenance, the thermal destruction system shall have a geometric Mean Time to Repair ($MTTR_g$) of less than four (4) hours 95% of the time and a Maximum Repair Time ($M_{max}$) of less than twelve (12) hours 95% of the time. Repair times do not include the time required to cool down or heat up the thermal destruction system. Organizational maintenance shall include any maintenance required during ship deployments, which are up to 6 months in duration. Organizational maintenance shall not require skills beyond that which is expected of an enlisted sailor with a 12$^{th}$ grade level of education. All other maintenance required to maintain function for the 25-yr. life expectancy shall be performed by an intermediate level maintenance organization. Intermediate level maintenance is to be performed by trained government repair specialists or contractors and is to include any major maintenance required to ensure safe and reliable operation for a 6-month deployment.

3.15.5 U.S. Navy Ship Material Compatibility.

In addition to the material requirements described in ASTM F1323-98 Standard Specification for Shipboard Incinerators, the following requirements shall also be met. The materials used to fabricate the thermal destruction system shall be compatible with the Naval/marine environment, including the salt-water environment, ship structural vibrations up to 40 Hz, and ambient temperatures of up to 120°F (49°C). The salt-water environment includes mist and condensation entering from compartment ventilation.

3.15.6 Process Compatibility.

Refractory material shall have a life expectancy of at least 10 years. Materials used in parts that are to be replaced on a preventative maintenance schedule shall have a life expectancy of 150% of that part’s expected service life. All other materials, including those subject to exposure from the waste being processed, or to the gases and liquids formed from the thermal destruction system process, shall have a service life of at least 25 years.

3.15.7 Paints and Coatings.

No chrome or lead paints shall be used. Paints and coatings used shall be suitable for a marine environment. Abrasive blast surface preparation shall be in accordance with SSPC-SP10 or NACE standard No. 3 to a profile depth of 1.5-2.5 mils maximum. Paint shall be applied within 4-hr. of surface preparation with VOC compliant paint to a dry film thickness of 4-6 mils. The adhesion between the primer and topcoat shall be tested by using ASTM D-4541 procedure. This testing shall be done by using a portable adhesion tester.

**3.16 Human Engineering.**

The thermal destruction system shall conform to human engineering principles to the degree that it can be operated and maintained by a 5-ft (152-cm) tall male or female as well as 6-ft 1-in. (185-cm) tall male or female. Its design shall also reflect system and personnel safety factors, including the elimination or minimization of the potential for human error during operation and maintenance, under both routine and non-routine or emergency conditions. Machinery, systems, equipment, and fixtures shall be intrinsically safe as far as practicable, and in the event of failure, shall fail to a safe mode. Man-machine interfaces shall minimize both the potential for and the consequence of human error. The level of training required for operating personnel shall be no more than four hours of on-the-job training; training required for maintenance personnel shall be no more than eight hours.

**3.17 Airborne and Structureborne Noise**

Airborne noise shall meet the noise limits in SNAME T & R Bulletin No. 3-37 that provides design guidance on shipboard airborne noise control. Noise absorbing material cannot be used on the bulkheads. The requirement to meet MIL-STD 740B for structureborne noise shall be predicted using Dynamic Design Analysis Method's (DDAM) or other acceptable method.

**3.18 Shock and Vibration.**

The system shall be free from vibration that could result in damage or the potential of damage to the ship structure, machinery, equipment, and system. For protection from ship-induced vibration all system components including control panel shall have no resonant frequencies below 40 Hz. The system shall comply with ISO 6954. The system shock performance shall be predicted using Dynamic Design Analysis Method’s (DDAM) or other acceptable method to show compliance with meet MIL-STD-901C for Grade B shock.

**3.19 Safety.**

The thermal destruction system shall be safe under both normal and unplanned conditions in accordance with the requirements of MIL-STD-882. As part of this effort, a Failure Modes and Effects
Criticality Analysis shall be performed by the offeror to evaluate the impact and likelihood of all conceivable failures. This shall include as a minimum, accidental introduction of materials that are not recommended for processing and loss of any or all services as listed in section 3.2. The following types of failures are not acceptable as part of the thermal destruction system:

- Catastrophic failures that result in death or system loss and are of remote likelihood to occur.
- Critical failures that cause severe injury, illness, or major system damage and are of probable likelihood to occur.
- Marginal failures that cause minor injury or illness or system damage and are expected to occur frequently.

The following failures shall be minimized to the greatest possible extent:

- Catastrophic failures that are of improbable likelihood to occur.
- Critical failures that are of occasional likelihood to occur.
- Marginal failures that are of probable likelihood to occur.

Note: The accidental ‘Typical Incidental Items’ are considered to be occasional for all items.

3.19.1 Forbidden Materials.

No asbestos shall be used in the construction of the thermal destruction system or any subsystem, including gaskets or lagging materials. In addition, mercury, cadmium, polychlorinated biphenyl's (PCBs) and chlorinated plastics shall not be used.

3.19.2 Exterior Surface Temperature.

No exterior surface temperature anywhere on the system shall exceed a goal of 140°F.

**4. DELIVERABLES.**

**4.1 Advanced Liquid Waste Thermal Destruction**

The basic contract is for the purchase of one liquid waste thermal destruction system, complete with the equipment described in section 3 of this SOW, and any special equipage required for its operation and maintenance (**CLIN 0001AA**). In addition, the contractor shall provide sufficient spare parts to support one year of daily operation **(CLIN 0001AB).** The thermal destruction system shall be delivered complete with a commercial-grade technical manual that provides step by step operating and maintenance instructions in English and with all measurement units (both the figures and text) provided in English units (and in metric units as well if the system is dimensioned in metric). If not included in the technical manual, schematics or drawings showing spare parts breakdowns shall be provided. There is a contract option for a second liquid waste thermal destruction system identical to the first one (**CLIN 0003AA)** including sufficient spare parts to support one year of operation (**CLIN 0003AB**).

**4.2 Thermal destruction system Compliance Presentation.**

(CDRL A001 of the DD FORM 1423)

A report shall be provided to detail the thermal destruction system's compliance with the requirements detailed in section 3. Oral presentations shall be made to the Government to summarize the thermal destruction system's compliance with each of the requirements detailed in section 3 of this proposal **(CLIN 0001AC).** The oral presentation shall be given after the requirements have been analyzed and before a letter or report certifying compliance is delivered **(CLIN 0002, CDRL A002 of the DD Form 1423).**

**4.3 Thermal Destruction System Compliance Certification Letter.**

(CDRL A002 of the DD FORM 1423)

A report **(CLIN 0002)** shall be provided to certify the thermal destruction system's compliance with the physical and operational constraints detailed in section 3. It shall include as enclosures a paper and electronic copy of the presentation and backup material in Section 4.2.

**4.4 Installation Guidance Drawing.**

(CDRL A003 of the DD FORM 1423)

An installation drawing **(CLIN 0002)** shall be provided for the thermal destruction system that includes all of the data described in section 3.2, including the following:

- Center of gravity
- Foundation interface
- Location and details of all interfaces
- Utility requirement details

**4.5 Thermal Destruction System Compliance Report.**

(CDRL A004 of the DD FORM 1423)

A detailed report **(CLIN 0002)**, complete with engineering analysis, shall be provided in order to validate the manufacturer’s assessment that the can process the target waste stream as described in section 3.6. The analysis described below must show that the entire targeted waste stream of 1783 liters/day (471 gal/day) can be processed in a 24 hour time period, minus the times necessary for startup, shutdown and for planned and unplanned maintenance. The report must also assess the impact of typical incidental items on the thermal destruction system operation and safety.

4.5.1 Planned and Unplanned Maintenance Time Calculation.

The report shall first calculate a maximum unplanned maintenance, which shall be defined as the 95$^{th}$ percentile of corrective repair times ($M_{max95}$with 95 percent confidence). The maintenance tasks used to calculate $M_{max95}$ shall include all anticipated repairs that would be conducted by ships’ force. The following calculation shall be used, with $\ln(X_{ci})$ being the natural log of each maintenance time and $n_c$ being the number of maintenance tasks:

$$M_{max95} = \left(\frac{\Sigma \ln(X_{ci})}{n_c}\right) + 1.645\sqrt{\frac{\Sigma\left(\ln(X_{ci})^2\right) - \frac{\Sigma \ln(X_{ci})^2}{n_c - 1}}{n_c - 1}}$$

For this calculation, the maintenance times shall include 1-hr. for acquisition of any spare parts. The total preventative and corrective maintenance time would then be calculated as the sum of $M_{max95}$ and daily planned maintenance time.

4.5.2 Daily Operating Time.

The daily operating time shall be calculated by subtracting the following times from a 24-hour period:

- Estimated startup and shutdown times,

- Ash removal downtime and
- The maximum single day preventative and corrective maintenance times calculated in paragraph 0.

4.5.3 Acceptable Processing Rate.

The acceptable processing rate shall be calculated as the amount of the targeted waste stream divided by the daily operating time. A detailed analysis shall then be performed to validate that the thermal destruction system is capable of reliably processing the entire target waste stream within each 24-hr. period, including downtime. To the maximum extent possible, calculations shall be based on performance data of an existing thermal destruction system. Calculations shall take into account incineration inefficiency due to known factors such as the changing heat values of the in feed.

4.5.4 Maintainability and Reliability Calculations.

Calculations shall be provided to assess the thermal destruction systems mean time between critical failure (MTBCF), mean time to repair ($MTTR_g$), and maximum unplanned maintenance ($M_{max}$) against the requirements of section 3.15. Where possible, calculations shall be based upon actual maintenance and reliability data.

4.5.5 Compartment Heat Load

The heat release from the incinerator into its compartment shall allow for an installation design that can provides a habitable environment with regard to temperature/heat transfer. A heat load calculation for the compartment shall show that ventilation requirements do not require air flows exceeding 100-ft/min, assuming that the total compartment volume is 14-ft x 16-ft x 7.5-ft high, and that the maximum air temperature cannot exceed 20-degrees above ambient. A heat load calculation shall be provided with schematic(s) and/or figures that show calculation assumptions and provide recommendations for installation that will control heat transfer and provide a habitable environment for the operator.

4.5.6 Shock and Vibration.

A vibration model and its Dynamic Design Analysis Method (DDAM) analysis shall be provided, including an electronic computer and printout copy of the finite elements, to show that the thermal destruction system does not have any resonant frequencies below 40 Hz. A DDAM assessment of the thermal destruction system’s resistance to Grade B shock shall also be provided. This shall include the level of shock at which the thermal destruction system structure is subject to releasing flying debris.

**4.6 Safety Assessment Report**

(CDRL A005 of the DD FORM 1423)

A safety assessment report **(CLIN 0002)** shall be provided to analyze the thermal destruction system’s safety in accordance with section 3.19. It shall be prepared in accordance with MIL-STD-882. The report shall include a failure modes and effects criticality analysis that addresses all conceivable failures and assesses the results of such failures, including their severity and probability of occurrence.

**4.7 Monthly Status Reports.**

(CDRL A006 of the DD FORM 1423)

The Contractor shall provide a Status Report **(CLINs 0002 and 0004)** on a monthly basis that shall describe the technical status of each task area. The report shall describe the work accomplished during each reporting period and its relationship to the statement of work, problems encountered, significant results, appropriate recommendations, and an outline of work planned for the next reporting period.

**4.8 Meetings and Visits.**

A minimum of two meetings with the contractor shall be held. The first meeting, to be held at the contractor’s facility, shall be a kickoff meeting to clarify plans, actions, and milestones. A second meeting will be held at either the contractor’s facility or at NSWCCD. The purpose of this meeting shall be for the contractor to make the presentation described in section 4.2. In addition, the Government may make visits to the contractor’s facility to monitor progress and exchange information.

**4.9 Installation and Checkout Support.**

The contractor shall provide installation and checkout assistance upon delivery of the thermal destruction system.  This assistance shall include the following:

4.9.1 On-Site Assembly.

The contractor shall provide for the assembly of the thermal destruction system on-site (i.e. at the location of delivery) in West Bethesda, MD if it is not shipped fully assembled.  This shall be limited to contractor-provided materials, parts and equipment. The contractor shall also provide sufficient information and guidance to ensure proper installation.

4.9.2 On-Site Checkout.

The contractor shall participate in the initial light off of the thermal destruction system to verify that it is functioning as designed. All operational features, including the correct and calibrated functioning of all components, shall be verified.

4.9.3 On-Site Training.

The contractor shall provide at least two days of training in conjunction with the on-site checkout to Government Technicians and Engineers. This training shall be sufficient to ensure that these trained personnel can operate the equipment safely and utilize all of its features.